Data Center Dashboard Demonstration

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A Report of BPA's Energy Efficiency Emerging Technologies Initiative

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Abstract

This project was a regional demonstration sponsored by the Bonneville Power Administration and Seattle City Light. Funding was provided to assist demonstration sites in the purchase and installation of hardware and software required to implement a dashboard system at its data center operation. These dashboards, also referred to as Data Center Infrastructure Management (DCIM) systems, track data center operations in real time. They provide actionable information and analyses for management of: IT equipment, space allocation, power systems, and cooling systems. The demonstration project was conducted to evaluate how DCIM systems could be used by operators as a tool for managing energy consumption, how they could assist in quantification of energy savings for utility incentive programs, and to highlight best practices for maximizing the value of this emerging technology.

BONNEVILLE POWER ADMINISTRATION
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Table of Contents

Executive Summary

The Seattle City Light Data Center Dashboard Demonstration was a regional demonstration project sponsored by the Bonneville Power Administration (BPA) and Seattle City Light (SCL) to fund and assist three demonstration sites to purchase and install hardware and software required to implement a dashboard system at its data center operation. These dashboards, known within the sector, as Data Center Infrastructure Management (DCIM) systems, can track Information technology (IT) equipment status and provide actionable information and analyses for management of: IT equipment, data center space, power, and cooling.

The demonstration project was conducted to develop publicly available references and identify best practices in the implementation of this emerging technology as a tool to optimize data center operations and energy consumption. It was also intended to outline benefits for utility efficiency programs that accrue from adoption of dashboard systems in data centers. The pilot also sought to determine if placement of a physical dashboard monitor in the data center would have any effect on operators' energy consumption. It was intended to be a very open-ended exercise to see how data center operators could or would use a dashboard system to optimize their operations.

Because most of the participants in this pilot represented the facilities function of their respective organizations, results were primarily focused on increasing the efficiency of data center cooling systems. Two of the three sites participating in this pilot were able to produce significant cooling system energy savings. The site that has not achieved energy savings to date is in the process of implementing a charge-back mechanism and accounting system for each business unit utilizing their data center. They will use this system to encourage virtualization and deployment only of servers that are actually needed. They expect to reduce physical server count by 5% – 10% through use of the dashboard to better manage equipment use in the data center.

The pilot illustrates that a dashboard system is a very effective tool for facility operators. While these systems did not provide direct control of the data center cooling systems, they did empower motivated facility operators with the data needed to effectively optimize energy use without negatively impacting reliability of the data center. The systems were very effective in enabling operators to document operational savings to management and provided confirmation that desired environmental conditions were being maintained, or improved. In one case, the facility operator would not have pursued efficiency measures without the verification of performance provided by a dashboard system. Measurement & verification of efficiency measures in these pilot sites, as well as at other data centers that have implemented efficiency measures has been another key benefit provided through use of a dashboard system.

Despite these benefits, SCL does not currently plan to offer incentives solely for implementation of data center dashboard because a monitoring dashboard still relies on intervention by the facility operator to act on the system data and implement efficiency measures. Installations of dashboards that directly control cooling systems are eligible for incentives under SCL's custom incentive program. Those incentives are based on the expected kilowatt hour (kWh) energy savings from using a control system that better matches cooling system operations to the actual cooling load of the data center. Monitoring only dashboard costs are eligible for inclusion in the calculation of incentive funding for efficiency efforts that include installation of a dashboard along with other measures, such as hot/ cold aisle separation.

The dashboard systems have significant potential for future utility program use in estimating savings from IT equipment efficiency measures. Most IT equipment currently in use does not scale power consumption with actual compute utilization. As new technologies for power management of IT equipment are developed more granular power monitoring will likely be necessary to offer appropriate utility incentives to encourage adoption of power management technologies.

Ultimately, each participant in this pilot indicated that use of a dashboard system enabled them to more efficiently operate their data center. These systems centralize data that is currently stored in disparate formats, or not being collected at all. They enable an organization to focus more on optimizing operations and utilization of their data center.

Project Background

Data center and IT operations are significant consumers of energy throughout the United States and in the Pacific Northwest. According to research conducted by the Northwest Power & Conservation Council, enterprise and mid-tier data center loads in the region are over 300 Megawatts, and could nearly double in the next decade. The desire for utilities in the region to become more engaged with data center operators and encourage higher efficiency led to the creation of this demonstration project. Learning how data center operators and utilities can best leverage dashboard technology to increase efficiency will have significant benefits for the region's power supply.

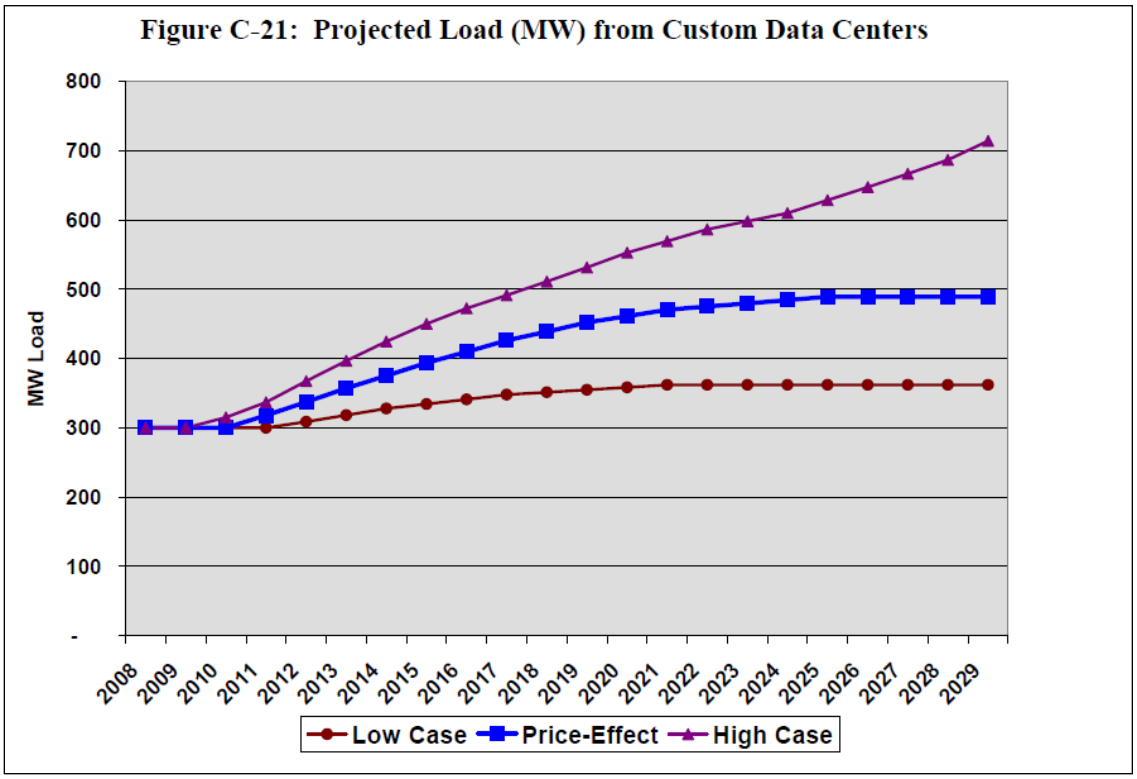

Figure 1: NW Power & Conservation Council projected load growth of enterprise and mid-tier data centers

Dashboard Technology overview

A data center operation typically has several stakeholders responsible for its operations. In most organizations, responsibility for the data center tends to be divided among two or three primary stakeholders. IT (Information technology) is responsible for servers, networking, storage, and software applications running in the data center. The facilities group is usually responsible for the power and cooling infrastructure of the data center. The third group of stakeholders, whose level of involvement varies by organization, includes the finance or executive management team.

DCIM or dashboard products currently available tend to serve one group very well and are less than optimal for the other stakeholders. The "holy grail" for dashboard systems is for a single application that captures the metrics and key performance data desired by each of these groups. The DCIM market is rapidly moving to address this need, but commercial DCIM applications still tend to have been built for either IT or facilities groups. Often additional modules or connections to other applications to address the needs of other data center stakeholders are available, but there is often still a primary focus on one organizational need in the application.

*DCIM tools monitor, measure, manage and/or control data center utilization and energy consumption of all IT-related equipment (such as servers, storage and network switches) and facility infrastructure components (such as power distribution units [PDUs] and computer room air conditioners [CRACs]).
**Gartner Research definition*

Figure 2: Dashboard / DCIM definition and scope

Examples of organizational units, their typical area of responsibility in managing the data center, and a small sample of dashboard applications with a primary focus on the needs of each group.

Organizational Unit	IT / Operations / Finance	Facilities
DCIM Uses	Asset Management Capacity Management Network utilization Power & Environmental monitoring Alarming	Alarming Control of HVAC / Power infrastructure Power & Environmental monitoring Trending of data points
Example Applications	CA Technologies Emerson – Trellis / IBM Nlyte Raritan DC Track	Bldg Management System "Add-ons" Automated Logic Corp., ATS, JCI, Siemens APC - StruxureWare Emerson Site Scan FieldView Synapsense Vigilent

Table 1: Dashboard functionality and example applications

Methods

Sites were recruited to participate in the demonstration based solely on an expectation that they would report on their experience in the selection and use of a dashboard system. Implementation of energy efficiency measures was not a requirement for participation in the pilot. Each site received funding of approximately 25% - 45% towards the cost of their dashboard system. The end goal of the demonstration was to produce qualitative information about the uses of dashboards for data center energy management and their use in support of utility incentive programs.

Demonstration sites

A number of prospective sites were approached about participation in the pilot. It was not easy to identify sites in this sector that were willing to publish results and meet time line goals for the demonstration project. Ultimately, time lines had to be extended several times in order to complete the pilot. This is a reflection of the pressures and conflicting priorities faced by data center operators in maintaining day to day support of an organization's computing needs with the desire to better manage data center operations.

The three sites that were selected for this pilot project were:

- The Westin Building Exchange Colocation suite
- Fred Hutchinson Cancer Research Center
- King County Government Data Center

Two organizations participating in the pilot were represented primarily by facilities personnel. One of the organizations was represented by the IT operations section.

Dashboard System Selection

Each site developed its own criteria for selection of the dashboard system that would be implemented. However, each participant's system had to be able to capture a minimum prescribed set of environmental and power consumption parameters (see Appendix 1) to participate in the pilot. Each site was also required to post a physical display monitor of the dashboard in the data center, or an area visible to data center operators / stakeholders (IT staff, customers).

These dashboards were used to provide tracking of energy consumption by end use (IT equipment, HVAC-Heating, Ventilation, & Air Conditioning systems) within the data center. We also required each to have dashboard systems that would track environmental conditions in the facility as well as weather conditions. Tracking these factors through the dashboard system allows for analysis of independent variables, such as weather on HVAC system operations. Tracking environmental conditions in the data center facilitates analysis of how changes in set points can impact HVAC and IT energy consumption.

Trending energy consumption of IT equipment, especially by Power Distribution Unit (PDU) or individual equipment Rack Power Distribution Unit (rPDU) provides the capability to analyze energy conservation measures at the rack or device level.

The choice of dashboard systems by each organization aligned with the way systems are currently designed and sold in the marketplace. Participants representing the facilities department installed dashboards that were extensions of systems provided by vendors of building management systems. The organization represented by the IT operations group deployed a dashboard that was primarily designed for space and asset management, and had been merged with a separate application designed to track power and cooling systems.

Each participant chose a system that provides a graphical representation of the data center's floor plan that displayed key indicators of real time power usage and environmental conditions.

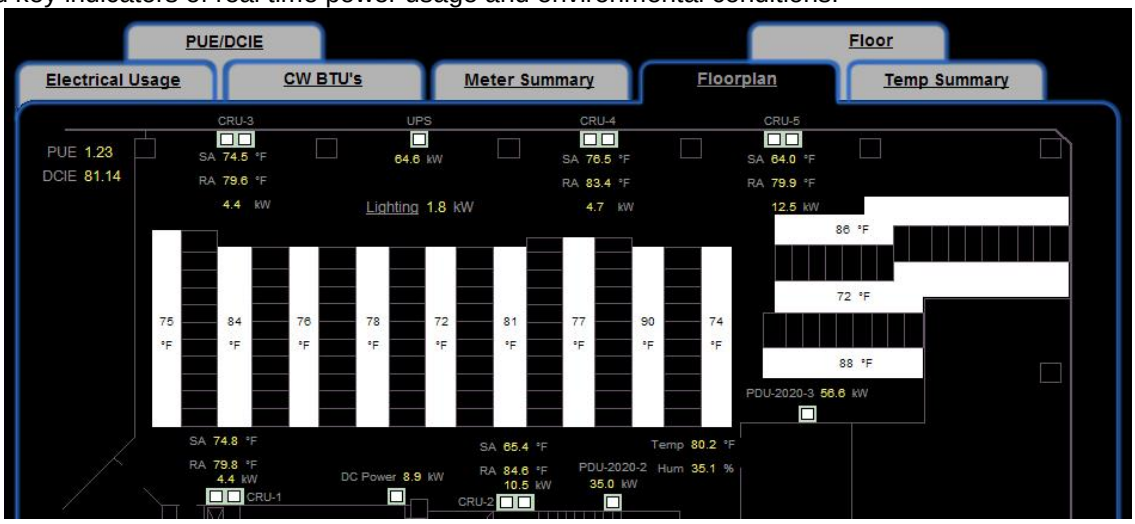

Figure 3: Westin Building Dashboard floor plan view

Some dashboards include the ability to graphically display rack and / or power utilization for quickly representing the status of data center capacity to stakeholders.

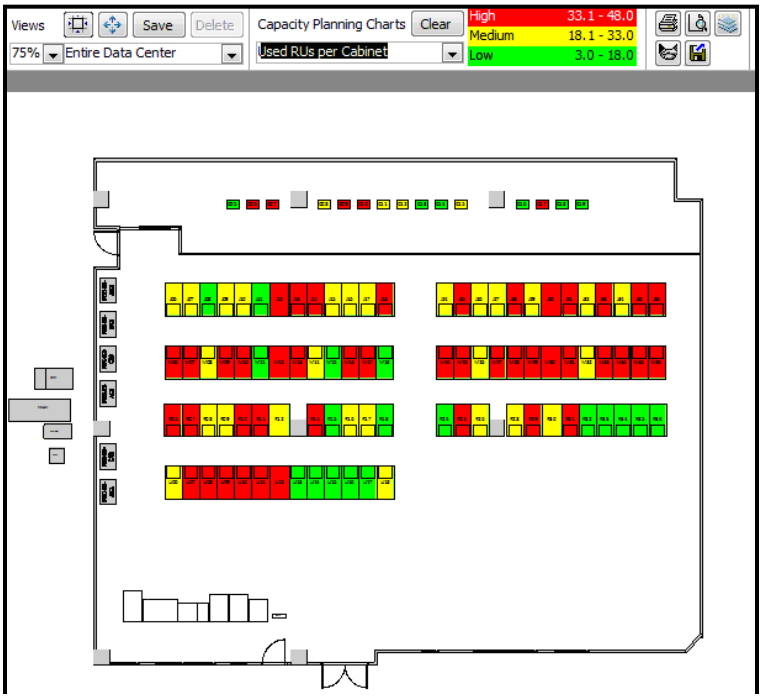

Figure 4: King County Data Center Floor Plan Graphic

Findings

Implementation

Installation of dashboard systems can be quite complex. The more granular the data acquired by the dashboard, the greater the complexity of setting up the system. Dashboard systems that track only power and environmental conditions are generally easier to implement than a system that includes asset, space, network, and IT equipment utilization. This is especially true if manual entry and configuration of assets and monitoring points is required. For example, manually collecting server and Power Distribution Unit (PDU) plug relationships and server / network port relationships for hundreds to thousands of servers represents a significant data collection task for existing staff.

Implementation was generally smoother, and went faster when the dashboard system was fully installed by the vendor. Implementations that depended on existing staff and involved documentation of asset details were often delayed by conflicting organizational priorities. Centralization of these details greatly enhanced an organization's ability to manage the data center, but it was no small task to create that database while maintaining operations of the facility.

Integration of dashboard data from external sources tended to present some difficulties for incorporation into dashboard systems as well. Despite use of open communication protocols operators reported occasional difficulties importing and maintaining data feeds from existing building sensors into their dashboard systems.

One participant indicated that a dashboard system of some sort should be a standard practice or a requirement for operating a reliable data center. Participation in the pilot did require each site to deploy additional

environmental and power monitoring sensors above and beyond what they would have utilized on their own. Several of the initial monitoring plans specified just a few wall mounted temperature sensors located in the data center space. The pilot required monitoring of space temperatures at the server rack inlet and outlet. This allowed operators to better manage and optimize operation of their cooling systems to meet cooling requirements of the IT equipment. At the conclusion of the study each site indicated that they felt the additional sensors were worthwhile and increased the value and usability of their system.

Dashboard Costs

The cost of implementing a dashboard system is very difficult to quantify. The wide variation in types of systems and pricing models employed by manufacturers makes it virtually impossible to make an even comparison of costs. In addition to capital expenses, implementation can be very time consuming and impose additional hidden costs. Especially, if the bulk of the dashboard installation is to be completed by an organization's existing staff. An installation that is completed 100% from a system vendor at a high initial capital cost may have a lower total cost than one installed by internal staff.

The table below presents system costs broken out on a per square foot and per monitoring point basis for dashboard installations funded by this project, as well as one other DCIM demonstration project previously funded by Seattle City Light. Examining dashboard system costs on the basis of data center size or number of points monitored highlights that costs for these systems vary widely.

Data Center Type	Cost per Square Foot	Cost per Monitoring Point
Colocation data center; all inclusive for hardware and software	$19.46	$596
Enterprise data center; 3yr software maintenance included	$13.29	$1,049
Enterprise data center; 3 yr. agreement for 125 racks – only monitors IT equipment. Cooling power & status monitored separately	$8.67	$694
Enterprise data center; leverages existing Building management system	$7.20	$1,385

Table 2: Dashboard system cost breakdown

Dashboard System Uses

The participants in this pilot consisted primarily of facilities and operations segments of their respective organizations. Not surprisingly, most dashboard system uses revolved around optimization of environmental conditions (cooling) of the data center.

The Westin building facilities management team used its dashboard as the basis for a comprehensive airflow optimization project. This effort included installation of hot and cold aisle separation, adjustment of set points (increased supply air temperatures). Without the monitoring of data center operations provided by the dashboard these measures would never have been implemented. The presence of the dashboard system allowed the facility to optimize operations while ensuring that environmental conditions were being maintained in accordance with the Service Level Agreements (SLA's) that are part of the lease agreement between the Westin and its customers. The dashboard also provided verification of improved performance and energy savings to The Westin Building management and Seattle City Light.

Verification of the efficiency gains has led The Westin Building management to expand adoption of the dashboard to other data center spaces they operate. They are also pursuing additional efficiency measures and utility incentives based on the successes documented through the pilot dashboard installation.

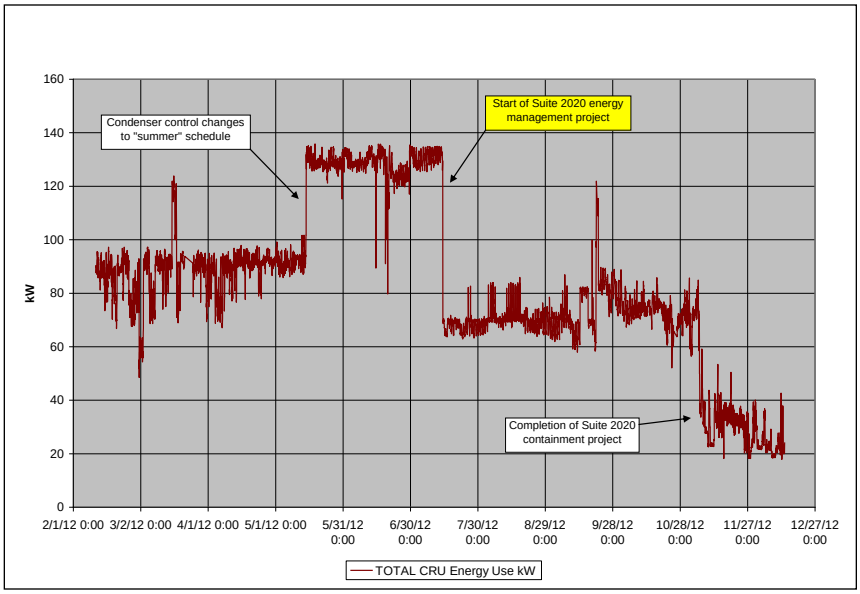

Figure 5: CRAC Power Trend data provided by the Westin Building Dashboard for verification of energy savings

King County's data center found great use in having visibility to real time data center operations by IT and operations staff from off site locations. King County's data center is in a leased facility outside of the main county offices. It is staffed 24x7 by county IT operations staff, but many stakeholders and managers of the data center work in offices not located at the facility. The ability to access real time operational details when not physically on-site has simplified the process of managing the facility, and has made it easier to effectively track operations. IT managers use the dashboard to cross reference electrical charges from their landlord, manage capacity and IT equipment deployment, and to track power usage.

Fred Hutchinson Cancer Research Center (FHCRC) installed its dashboard as part of a new data center build out in an existing building. The dashboard was used extensively by the facilities staff in the commissioning process to optimize operations of the supply fans. Once operational, the data center facilities staff used the dashboard to institute a supply temperature reset strategy to further reduce airflow and provide additional use of outside air "free cooling" in the data center.

The IT staff at FHCRC also uses the dashboard to assist in capacity planning and to assist in decisions regarding physical server deployment in the data center. IT has been using the dashboard for capacity management, space planning, and tracking utilization.

FHCRC also reported that use of the physical dashboard monitor at the data center has been a key element in communicating the story of the data center's efficiency and reliability to management and stakeholders. As a high profile cancer research center, FHCRC conducts an average of two data center tours per week. Their dashboard is the focal point for these tours. It provides a concise, detailed view of the data center's role in supporting their core research work.

Bob Cowan, Director of Facilities at FHCRC reports:

"*We believe we have one of the most energy efficient data centers in the world and the dashboard allows us to demonstrate that and to even improve upon the inherent energy efficiency in the design. We've had over two hundred IT and Facilities Specialists tour the Data Center and the starting point is always the dashboard; it allows the story to be told, the energy efficiency to be shown and the design concepts to be demonstrated in one*

graphically pleasing way. We believe our Data Center will set the standard for the future and the Dashboard is central to this design shift that is shaping the future of Data Centers".

Figure 6: Fred Hutchinson Dashboard Graphic

Operational efficiency gains

Better tracking and centralization of information about each data center was a theme that emerged from this pilot. Each site reported that dashboards greatly improved their ability to manage and track data center operations and performance. Less time was required to physically walk the floor of the facilities to monitor operations. Accuracy and consistency of data collection from each facility was greatly enhanced by the presence of a dashboard system.

Having more readily accessible information about the facility made it easier to examine opportunities to improve operations and efficiency. Tracking and reporting key operational metrics about the data center to participants' executive management teams has also been simplified and enhanced by the dashboards.

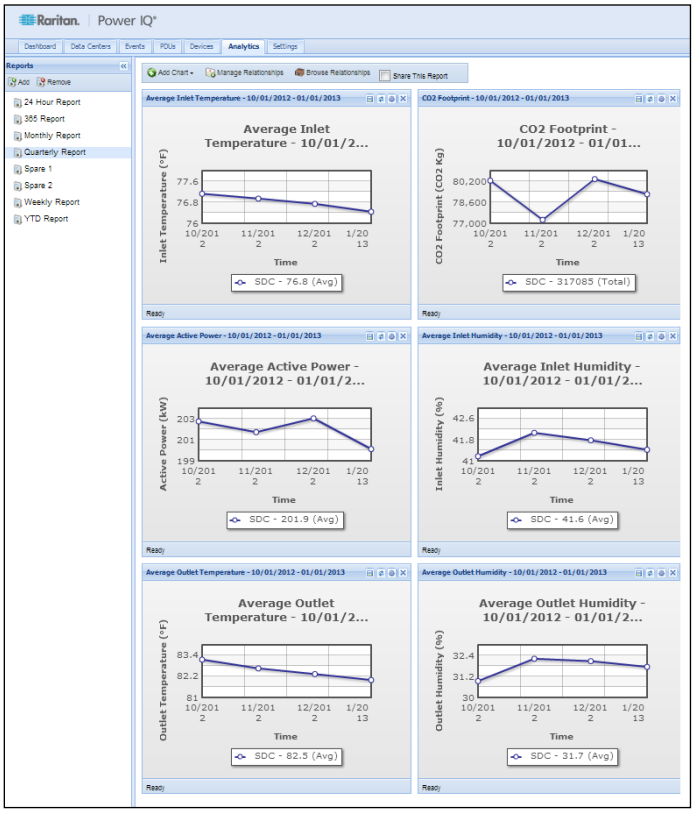

Figure 7: Quarterly report of data center environmental conditions provided by King County dashboard

Detailed data about HVAC system operations and the data center environment provided by the dashboards provides early warning for issues with equipment / space conditions. Dean Collins, Project Director at The Westin Building reported, *"I can tell by looking at the dashboard if a tenant has left a door open in the cold aisle."*

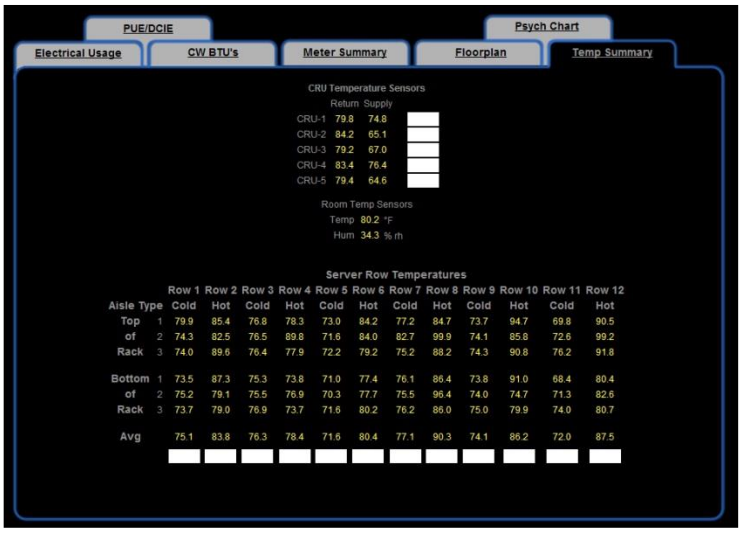

Figure 8: Tabular view of aisle temperatures from The Westin Building dashboard

The dashboards are also very useful in visualizing the potential impacts of new equipment deployments or quickly assessing the impacts of operational changes in the data center. The ability to quickly generate reports and trend operational parameters over user selected time intervals was reported to be a key benefit of the dashboard systems.

Actions Taken

All of the participants have integrated use of the dashboard into daily management of their data centers. They all are more closely monitoring energy use of their facilities because it is now part of their stream of operational data. Each of the data centers is monitoring PUE (Power Usage Effectiveness) in real time. Sudden changes in the PUE of a facility are an indicator of cooling system malfunctions, or other operational issues in the data center.

The Westin Building has utilized the dashboard as a vehicle to implement hot/cold aisle separation in their operations. The detailed monitoring it provides served as proof of concept. The dashboard illustrated that energy required for cooling could be reduced, while still adhering to SLA's in customer leases. The dashboard system provided documentation that space temperatures in the cold aisles were much more consistent and uniform after the cold aisle containment was completed. Dean Collins, Projects Director at The Westin Building had this to say about use of their dashboard, "*This system has allowed us to operate smarter and with tighter controls."*

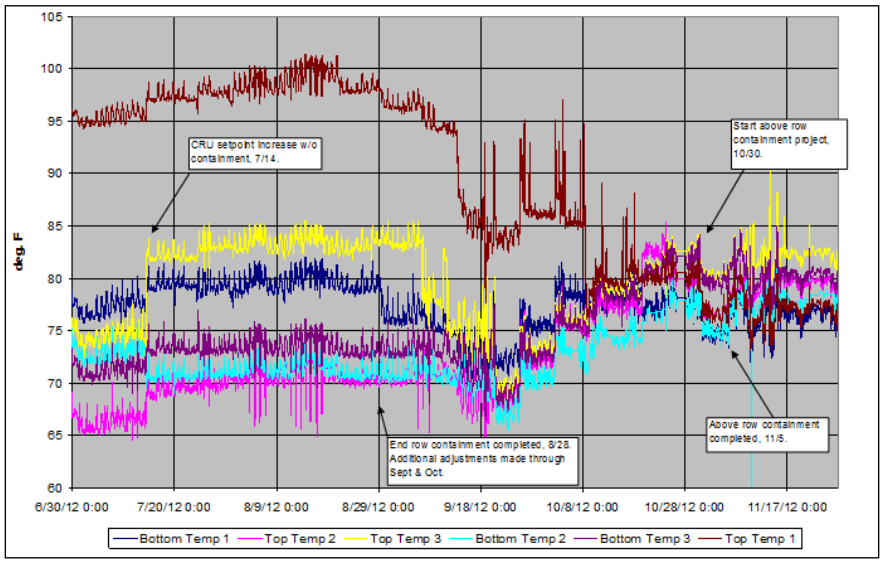

Figure 9: Cold aisle temperature trending documents more uniformity after containment installed

The Westin Building has used results of this pilot as a test case to expand dashboard use and aisle containment throughout other portions of the facility that they operate. These measures would not have been adopted without the presence of the dashboard system and the operational confidence that it provides.

FHCRC has pursued several incremental efficiency measures that would not have been possible without their dashboard monitoring. These improvements came from use of the dashboard to fine tune operational sequences for airflow, and supply and return air temperatures.

Key Dashboard Features

Each participant stated that having the ability to quickly assess operations of their data centers in real time was the most useful aspect of their dashboard implementation. Monitoring and trending of power and environmental conditions greatly enhanced the ability of the participants to manage their data centers on a day-to-day basis, optimize operations, and report the impact of changes or proposed changes to the data center. Below are specific features referenced as the most useful by the dashboard pilot participants:

- Powerful graphing and trending tools allow for detailed analysis over time
- Instant overview available visually through dashboard “gauges” and graphs
- PUE* (Power Usage Effectiveness) information is front and center to allow a quick check on systems
- Load Planning for IT is facilitated by quick reference to pod load and capacity
- Trend data allows us to quickly tell the operations story to visitors
- Generates discussions about our efforts and methods due to availability of information to non-technical users
- Tracking environmental conditions to see trending over period of time is helpful in space management.

**PUE is a data center energy efficiency metric, the ratio of total data center power / IT equipment power. 1.0 is the best theoretically possible PUE. Typical mid-size data centers have a PUE of 1.7 – 2.0 +*

Energy Conservation Measures

The participants all were able to use the dashboards to identify energy efficiency measures for their facilities. This was true even in newly constructed, or facilities that were already operating at a better than average energy efficiency compared to the average data center. The measures identified by customers in this pilot included:

- Hot / cold aisle separation
- Higher cold aisle, return air temperature set points
- Additional use of water side economization realized through higher set points
- Optimization of airflow delivery at the rack level (supply air duct vents adjusted)
- Supply fan airflow reduction
- Supply Temperature reset (Higher temperature differential reduced airflow by 20-30% from design)
- Reset supply air static pressure from 0.2” to 0.1”, further reducing airflow
- Identification of servers for virtualization / consolidation

Utility incentive funding was provided to The Westin Building for efficiency measures that were identified through use of their dashboard. Those efforts (hot/cold aisle separation, set point increases) produced an 11% annualized reduction in cooling system energy consumption (271,556 kWh) for their dashboard pilot location.

Value of Dashboard Systems for Electric utilities

Dashboard systems have significant value for use in utility energy efficiency programs. Some of the primary uses that are beneficial for efficiency programs include:

- Collection of trend data to establishing base line energy consumption for proposed incentive project(s).
- Verification of energy savings from completed efficiency measures.
- Confirmation that measures have been implemented without negatively impacting the reliability or environmental operating envelope of the data center.
- Better visibility of operating conditions highlights additional efficiency opportunities

Dashboard systems can also assist in development of programmatic base line metrics for energy consumption of commonly used data center HVAC equipment (Chiller kW/ton, fan energy use- cfm/kW, etc …). They can also provide evidence to support or amend assumptions regarding operational characteristics of data centers. These assumptions can be used in facilities where a dashboard system is not present, but similar installations of IT and HVAC equipment are utilized. A dashboard can also provide verification that system components (cooling towers, air economizers, etc…) perform as designed or expected.

Future Potential for Utility Use of Dashboard Systems

Dashboard systems are also likely to have greater use for utilities in the future as additional measures are developed for IT equipment. Current deployments of IT equipment tend to have relatively small variations in power usage compared to the amount of processing being done. Most IT equipment operates at low levels of utilization or idle mode the majority of time, but its power consumption is relatively constant. This is especially true in small to medium sized data centers that house the majority of servers in the US. (EPA 2007 Study)

Significant research is underway by IT equipment manufacturers to have power consumption scale proportionally with utilization. Measurement and tracking of IT power consumption via a dashboard system will enable utilities to evaluate effectiveness of these technologies as they are deployed. Appropriate incentives based on energy savings may be warranted, but more detailed data on IT equipment power consumption will be needed to make this determination.

Conclusions and Recommendations

A dashboard system can greatly enhance the operational and energy efficiency of a data center. Every organization that participated in this pilot reported that the dashboard greatly improved their ability to manage their facility, track energy use, and implement energy efficiency measures. Two of the three participating sites reported specific energy savings measures completed over the relatively short term of this pilot.

However, the dashboard alone did not produce the energy savings. Realizing these efficiency gains requires data center operators to analyze and act on data acquired by the dashboards. Maximizing the benefits of a dashboard system requires that an organization's policies and processes create the incentives and accountability that will ensure that the dashboard system is utilized to optimize the data center operations.

Use of the physical dashboard display in each facility was found to be valuable for communicating with internal and external data center stakeholders. However, the physical display did not have a direct impact on energy consumption in the data centers participating in this pilot. The physical dashboard display seemed to generate greater collaboration between facilities operators and IT staff. In the enterprise data centers participating in the pilot, the physical display provided a common frame of reference for IT and facilities staff to discuss data center operations. This is likely to produce energy savings, but it would be difficult to quantify the extent of savings that effect has on the facility.

The presence of a dashboard system does have significant value for utilities in administration of incentive programs. However, since most dashboard systems do not directly result in energy savings, it is not likely that they would be eligible for a standalone incentive under most utility incentive program rules. It is more likely that a dashboard system's costs would be eligible for inclusion in incentive funding calculations. A dashboard may also receive funding as at a "bonus" or higher incentive rate where energy efficiency measures are completed in a data center.

An organization's investment in a dashboard system can be an indicator that they are committed to more closely managing their data center operations and that the proposed energy savings measures are likely to persist, even if they are reliant on the actions of the facility's personnel to sustain the efficiency.

Utility Incentives for dashboard implementation

Seattle City Light (SCL) does not offer an incentive solely for use of a data center dashboard or DCIM system implementation. This demonstration project highlights that a monitoring system is a very powerful tool when used by an experienced, motivated facility manager. SCL has observed implementing dashboard systems results in significant energy savings. However, those energy savings were the result of the facility manager acting on data acquired by the monitoring system, and not directly the result of the system optimizing facility operations.

At SCL, dashboard system costs are eligible for inclusion with project costs for energy conservation incentives that include implementation of a dashboard system. However, they are not funded on their own as a conservation

measure. Funding for projects that include a dashboard as part of a larger efficiency effort is based on estimated annual kWh savings and expected measure life of the other measure(s) implemented.

Some dashboards are part of HVAC control systems, or have optional HVAC control modules. Those implementations are eligible for Seattle City Light custom incentive funding of up to $0.23/ kWh saved based on an expected measure life of 12 years for HVAC controls.

In two of the three sites participating in this pilot, additional temperature sensors were added at SCL's request. Additional sensors to monitor inlet and exhaust temperatures in the data center as well as sensors to monitor outside air dry bulb and wet bulb temperatures were installed with the systems. At the conclusion of the study, participants commented that the additional sensors were very worthwhile and that they provided actionable data about how to better manage the data center to improve reliability and efficiency. This may be an area where utility incentives may be justified, if tied to use of economizer cooling and/or higher temperature set points.

Dashboard System Best Practices

This section is biased towards use of dashboards in energy management and utility incentive programs given that the scope of this project and primary participants were primarily concerned with facility operations. It is not a comprehensive checklist for an organization to use in planning or deployment of a dashboard system. It is based on reflections of pilot participants, experienced facility operators who have been through dashboard implementation and use for the past 18 months.

Parameters to monitor

- Track IT equipment consumption – at UPS output or Power Dist. Unit (PDU)
- Track cooling energy consumption
- Track independent variables (outside air temp. rel. humidity, barometric pressure) – trend dry bulb & wet bulb temps.
- Deploy temperature sensors throughout the IT equipment aisles vs. 1-2 space temperature sensors to provide a better representation of actual conditions at the server inlet & outlet.
- Ensure the system tracks Key Performance Indicators (KPI's) that are meaningful at all levels of your organization

Correlating performance of HVAC equipment to weather conditions to track actual system operations with expected or design operation is especially important if the data center is equipped to operate in economizer or "free cooling" modes. The graph below shows data collected from a data center that was not part of this pilot. The facility monitors the chiller power consumption and outside air temperature. However, these two measurements are not correlated or compared regularly by the facility operator. The center is equipped with "free air" economizer cooling. Analysis of the facility's operations for potential utility incentive funding showed that the mechanical cooling (chiller) still operated at conditions where it should have been shut off because the data center was using outside air for cooling.

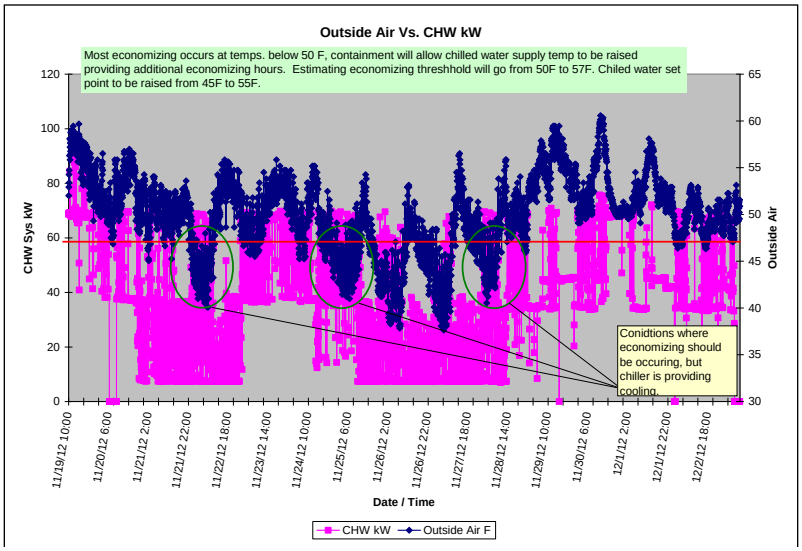

Figure 10: Trend of chiller power and outside air temperatures shows economizer not functioning as designed

The monitoring system was in place, but not set up to provide data that the facility operator could or would act on to optimize their facility operations. Using a dashboard only for monitoring and alarming of immediate data center reliability issues can miss the opportunity to highlight inefficient data center operations.

In contrast, the dashboard display in the Fred Hutchinson Cancer Research Center measures and displays detail about server and HVAC power use. Operations outside of design parameters are immediately evident to facility operators, and are more likely to be corrected quickly.

Figure 11: FHCRC power & cooling metrics from dashboard display

Implementation Tips:

- Flexibility is key – deploy a system that can be reconfigured or shared for multiple locations
- Ensure that user selectable reporting, graphing, and trending is part of your application
- Report metrics in a meaningful way, use Key Performance Indicators (KPI's) that relate to organizational or stakeholder goals
  - PUE, DCiE, annual energy cost/ server, Annual cost or kWh / production unit
- Maintain portability of data – Ability to export dashboard data in a format (.xls, .csv, .txt, .xml) that can be used for deeper analysis or for import into other applications.
  - It's important to ensure data is available for use in scenarios not envisioned in the selection process.
- Take time to ensure initial data entry and system set up is accurate
  - Garbage in Garbage Out!
- Limit administrative rights to maintain integrity of data entry
  - Adherence to naming conventions
- Establish processes and procedures for dashboard maintenance and backup – Don't set it & forget it!
  - Sensors need calibration, wireless units need battery replacements
  - Database software upgrades & maintenance
  - Some dashboard maintenance will be required!

This project has demonstrated that implementation of a dashboard or DCIM system greatly expands an organization's ability to effectively manage their data center operations. These systems deliver significant benefits to each stakeholder in the data center's operation. A dashboard system also greatly simplifies the process of providing utility incentives for efficiency measures installed in data centers. Utilities should certainly continue to encourage installation of dashboard systems in data centers.

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Appendix 1: Dashboard System Requirements

Participation in the pilot required that dashboard systems had to be able to track the following parameters:

- Power consumption of Information Technology (IT) equipment
- Power consumption of cooling equipment
- Representative measurement of inlet and exhaust temperatures at IT equipment racks (top / bottom, end & center of aisles)
- Temperatures of cooling system air streams (supply and return)
- Relative humidity
- *Measurement of air flow (fan Hz, %, or CFM)
  **If central air handlers supply the data center and have capability of variable flow. Not needed for constant volume fans or CRAH / CRAC units*
- Condenser loop flow rate
- Condenser loop temperatures (supply and return)

Data collection intervals shall be in periods of no more than 15 minutes, unless specified in writing with the approval of SCL.

Systems shall have reporting capabilities that allow data center staff to produce reports with separate kilowatt hour (kWh) consumption of IT and cooling systems for user selected time intervals.

The dashboard shall be displayed continuously on a physical display located in the data center, or in an adjacent location monitored by data center end users and operators.

Appendix 2: The Westin Building Exchange Summary

Background

- Carrier hotel, downtown Seattle, WA
- Dashboard in a colocation suite
- Owner only responsible for power & cooling

This dashboard was installed in a colocation suite operated by the Westin Building Internet Exchange facility. The suite is cooled by 5 direct expansion Computer Room Air Conditioning units (Dx CRACS) located around the perimeter of the room. The CRAC units provide cold air to the IT equipment via overhead supply air ducts and warm air is returned to the CRAC unit intakes (@ floor level) via an open pathway. Heat is rejected from the space by the building's condenser loop and cooling towers.

During the course of the dashboard demonstration project cold aisle containment was installed in this suite. Containment consists of sliding doors at the end of each cold aisle and vinyl curtains located above the equipment cabinets and above the door at the end of each aisle. These vinyl curtains did not extend all the way to the ceiling due to obstructions from cable trays and the fire suppression system. However, they do extend above the supply air ducts. Blanking panels were also installed in open rack units to reduce mixing between hot and cold aisles.

Net impact of the containment has been a dramatic improvement in consistency of supply air temperatures in the cold aisles. Return air temperatures and supply air temperatures have been increased by approximately 10 deg. F. Airflow volume has been maintained at the same level after the containment was installed. The operators experimented with reducing airflow by staging off constant volume CRAC units. The non-standard layout of the room resulted in supply temperature variations when CRAC unit(s) were staged off, so all units have remained operational. The containment and set point adjustments have provided many more hours when cooling can be provided by the building's condenser water (cooling tower) loop instead of CRAC compressors resulting in significant energy savings.

Dashboard Selection Process

The Westin Building team solicited bids from three providers and selected Sunbelt Controls' Automated Logic Corp. (ALC) system. This installation is used only for monitoring, and does not provide control over cooling equipment in the data center.

Items added per SCL requests:

- Outside Air temperature sensor (Existing sensor data imported into system)
- Additional space temp / humidity sensors in equipment aisles (Total of 72 sensors) throughout the collocation space. The initial deployment plan was for 12 temp sensors

Key to successful implementation

- Planning
- Use of a contractor experienced in deployment of monitoring and control systems. The vendor selected was a local distributor with a good working knowledge of the facility.
- Minimal use of data monitoring points that needed to be "imported" from disparate networks via bacnet, SNMP, or other external protocols.
- Continuous monitoring of the system and slow incremental operational changes provided the best results.

Dashboard System Use

- Allowed the facility to implement hot / cold aisle separation; raise supply & return temperatures.

- Used almost solely by building (facilities) management to monitor space conditions. This is colocation space and facilities needs to maintain environmental conditions in accordance with service level agreements (SLA's) in customer leases.
- Used to manage energy consumption – ensure that the space is using maximizing use of water side economization, it has been used to manage increases in set points for space temperatures.
- Used to measure base line energy consumption for a utility energy efficiency project (cold aisle containment).
- Power Usage Effectiveness (PUE) is now being measured for this suite. Use of PUE is helpful in comparing the relative efficiency of the suite, and also trending changes in its operational efficiency to building ownership and tenants.

Use by different business units (IT, Facilities, Mgmt. others)

- The ability to observe and track efficiency gains and understand the return on investment has helped tremendously with the approval of future energy efficiency projects.
- Facilities engineering is using the system to identify where environmental controls can be manipulated to increase efficiencies.
- Greater awareness by operations and engineering for real life environmental controls and efficiencies. This system has allowed us to operate smarter and with tighter controls.

Actions taken as a result of dashboard use

Implementation of efficiency measures – cold / hot aisle separation, raising of set points for space temperatures, additional water side economizing. The Westin Building would not have pursued these measures without the confidence that they were maintaining SLA's that is provided by the dashboard system.

Energy conservation measures identified

- Hot / cold aisle separation
- Higher cold aisle, return air temperature set points
- Additional use of water side economization

Energy savings realized

- Annual base line consumption (IT & HVAC) was 2,458,672 kWh
- Energy savings estimated via calculations - 182,083 kWh / Year; 7.4% estimated reduction
- 271,556 kWh/yr validated through use of the dashboard system; 11.0% actual kWh reduction

Most useful features of systems

1. Space temperature monitoring for verification of SLA performance
2. PUE calculation for simple communication of efficiency to external stakeholders
3. Ability to correlate HVAC power consumption to outside air conditions valuable in determining if economizer functions are working per design spec.
4. Powerful graphing and trending tools allow for detailed analysis over time.

Appendix 3: Fred Hutchinson Cancer Research Center Summary

Facility Background

- Enterprise data center, Seattle, WA
- Owner responsible for IT & facility operations

Fred Hutchinson Cancer Research Center (FHCRC) recently constructed this data center in a commercial office building. The building core & shell had been completed before being purchased by FHCRC. Once FHCRC assumed ownership the building was converted into lab, technical office space, and data center use in 2011 – 2012. It is a "new" data center build out, but the building was not initially designed for a data center.

The data center was constructed with four "pods" that contain IT equipment racks arranged into tightly separated hot aisles or rooms where warm server exhaust is removed from the space. Hot air is either mixed with outside air to deliver the desired supply temperature, or exhausted completely if warmer than desired supply air temperature. The data center floor serves as the cold supply air plenum.
Cooling is provided by a central fan array supply Air handler (AHU) that relies primarily on outside air and evaporative cooling. The building's chilled water loop supplies a coil in the data center, but the chiller is only used for cooling when outside air conditions are too humid or contamination is present. Chilled water cooling is used less than 250 hrs/ yr. given Seattle's cool climate and generally dry conditions during periods of warm weather.

This has proven to be a very energy efficient reliable data center design, but FHCRC staff has still been able to increase the efficiency of the data center through use of their dashboard.

Dashboard Selection Process
FHCRC selected an extension of an existing Siemens Building management system. This system is used throughout their campus and was chosen for the dashboard because Siemens is an existing vendor in which FHCRC has confidence and a familiarity with their products.

Challenges
Biggest challenges to implementation were related to communication of FHCRC's vision for the dashboard's usage. Then once the common understanding of dashboard usage was established having graphics created that effectively communicated that vision in a manner that was functional and easy to read.

Items added per SCL/ Dashboard Pilot participation requirements:

- Publicly viewable dashboard
- Additional sensors for temperature and power use.

Use by different business units (IT, Facilities, Mgmt. others)
IT has been using the dashboard for capacity management, space planning, and tracking utilization.

Facilities used the dashboard system extensively in the facility's commissioning process (this is a new data center). The control system for the FanWall supply fan system was not performing to expectations and the dashboard system helped document this disparity to the fan control vendor. The FanWall software was upgraded and supply fans are now operating per design spec.

The facilities team has also instituted a supply temperature reset strategy to allow supply temps. to float between 60-72 deg. When outside air temps are below 72 deg F. By increasing target delta T from ~20 deg. F to ~30 deg. F. reductions in airflow, of up to 30% are being realized.

FHCRC management is much better informed about the data center's operations and how its efficiency compares to a typical facility. The dashboard provides a reporting framework for facilities to document how their efforts to manage the data center are reducing costs.

The IT Manager, Steve LeVeck, reported that because of the dashboard his staff is much more aware of the energy consumption of the IT equipment, takes more care in deploying IT equipment in a manner that results in better utilization of the data center.

Top 5, or most useful features of systems

1. Instant overview available visually through dashboard “gauges” and graphs
2. PUE information is front and center to allow a quick check on systems
3. Load Planning for IT is facilitated by quick reference to Pod load and capacity
4. Trend data allows us to quickly tell the operations story to visitors
5. Generates discussions about our efforts and methods due to availability of information to non-technical users

Appendix 4: King County Government Data Center Summary

Facility Background

- Primary data center for county agencies
- Leased "suite" in a multi-tenant data center
- Facility owner monitors power & cooling

The King County data center (KCDC) is a leased data center suite. The data center is a physically separate space (not a colocation cage) from other suites in the building. However, cooling is provided by a common HVAC system that serves several adjacent suites. This type of data center is analogous to commercial building with several tenants that each manage their own separate leased spaces, but have some common utilities provided by the building owner. In this case the facility owner, Sabey Data Center Properties, is responsible for the provision of power and cooling to the facility. Sabey maintains a separate monitoring system that tracks energy consumption, PUE, and environmental conditions within the multi-tenant facility that houses the KCDC. King County is responsible for all of the data center operations within their suite.

KCDC is in a fairly new facility that was constructed in 2008 - 2009. Cooling is provided via a central air handling unit system (AHU's) that serves several adjacent data center suites. Cool supply air is provided to the room via overhead ducts and supply air diffusers throughout the data center. Hot air is exhausted from the room via "chimneys" from each equipment cabinet that vent into a ceiling plenum which keep hot air separated and returns it to the AHU's. Supply air temperature is maintained through use of evaporative outside air cooling w/ chilled water available for the ~250-500 hrs/yr. when outside air is not suitable for cooling the data center.

Dashboard Selection Process

King County data center operations, implemented a dashboard system that is primarily focused around environmental monitoring, data center capacity management, asset tracking, and power management at the rack / device level. This choice highlights their primary responsibility for managing data center operations in the only "white space" of the data center. The Sabey facility staff is responsible for management of the power and cooling systems.

The KCDC chose a commercial dashboard (DCIM) software package from Raritan a supplier of power distribution and data center infrastructure. They were interested in choosing a system that would integrate easily with their existing infrastructure, and they utilize a significant amount of power distribution equipment from Raritan.

Key participant selection criteria

- Operations wanted a product that would integrate easily with the existing data center power infrastructure
- Management desired an application that was available via a web browser to access the dashboard system when not at the data center, which is not located in the County's primary office locations.
- The customer also desired a dashboard system with an annual licensing expense vs. a large one-time expenditure to better align its use as an opex budget item.

Challenges

Information gathering for implementation, while a lot of information was already kept in spreadsheets, transferring and gathering additional data such as server / plug relationships in addition to port assignments has been a lot of work. Even with vendor implementation assistance getting dedicated resources for data entry has been a challenge.

Items added per SCL requests:

Dashboard display screen in DC Network Operations Center

Challenges

- Conflicting workload priorities impacted ability of existing KCDC staff deploy the system according to the planned rollout schedule.
- The dashboard system utilizes two separate software applications that the vendor originally marketed separately, and is in the process of combining into a single application. Underlying differences in the applications caused conflicts that had to be resolved via the vendor's technical support process.
- Populating the system was a primarily a manual process of validating spreadsheet inventories and tracking sheets for data center assets and bringing them into the system.

Key to successful implementation

Accuracy of information entered into DCIM is paramount. Any erroneous information can skew and invalidate space planning efforts quickly.

It is also key to keep the team managing the products very small, this is a case of too many cooks can spoil the broth. It can also cause deviations from standards and naming conventions in the product.

How is the system used by demonstration site?

- Event logs created by the system allow for analysis of anomalies / equipment failures
- Aids in contingency planning – dashboard allows for "Failure Mapping", which documents equipment / applications impacted by failure or partial failure of data center equipment
- Tracking and trending actual performance of cooling system to SLA's for environmental conditions in the data center
- Capacity planning, optimizing use of space, networking equipment
- Tracking power and space utilization to each business unit for accountability, and possible chargeback
- Concise reporting now available for KCDC management to report on costs, energy use. Develop action plans and track progress on cost reduction targets set by the executive team for the data center operations.
- Validating energy sub meter billing from the building owner

Use by different business units (IT, Facilities, Mgmt. others)

- IT Operations uses the system to manage space / capacity planning, network utilization
- The dashboard reports on device health
- The display plots the real time DC environmental conditions compared to the ASHRAE recommended conditions via a Psychrometric chart display

Operational efficiencies realized through dashboard use

- Better use of space in deployment of new servers.
- Identification of servers that are candidates for virtualization
- Simplifies reporting of energy metrics, greenhouse gas reporting- the dashboard software calculates these metrics instead of manual tracking via excel.
- Visibility to data center operations to KCDC staff located in other facilities

Top 5, or most useful features of the dashboard

1. Reporting for KC management
2. Validation of electrical billing from building owner
3. Ability to track utilization of data center by each customer (agency)
4. Tracking environmental conditions to see trending over period of time is helpful in space management.
5. Locating devices within the data center with ease for troubleshooting.